SYNOPSIS

AN EXPLORATIVE STUDY OF BAST FIBRES FOR THE APPLICATION IN MEDICAL TEXTILES

BY

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INTRODUCTION:

Like agriculture, textiles have been a fundamental part of human life since the dawn of civilization. Early people used linen and other materials collected from nature for their garments. For thousands of years the four natural fibers used by men were cotton silk wool and flax. Natural fibres provide a multitude of human and environmental health as well as economic benefits. Each fibre has its own purpose in manufacturing, and provides better quality and more sustainable textiles than synthetic materials. Natural fibres in clothing allow fabric to breathe, reducing the risk of skin rashes and allergic reactions, and also insulate the wearer against hot and cold temperatures.

With regards to environment, the use of natural renewable sources for the generation of textiles includes lowest practical ecological impact during various stages of processing of fibres in converting into textile products. They are also carbon neutral: they absorb the same amount of carbon dioxide they produce. During processing, they generate mainly organic wastes and leave residues that can be used to generate electricity or make ecological housing material. And, at the end of their life cycle, they are 100% biodegradable. They are biodegradable which means that during the disposal stage of their life cycle they decay through the action of fungi and bacteria. They can be composted which can improve soil structure, or incinerated with no pollutant emission and they release carbon that has been only absorbed during their lifetimes. The demand for natural fibers continues to increase because of their many outstanding properties, including aesthetics, comfort, and biodegradability.

In the fashion scenario, natural fibres designated by various names: sustainable, green, uncycled, ethical, eco-, even eco-environmental focusing concern for the environment, the well-being of fibre producers and consumers, and the conditions of workers in the textile industry. Young designers now offer “100% carbon neutral” collections that strive for sustainability at every stage of their garments’ life cycle – from production, processing and packaging to transportation, retailing and ultimate disposal. Scientists throughout the globe are frantically trying to use all possible sources for manufacturing eco-friendly textile fibres.

All these changes and concern for global environment in the minds of people all over the world has made them aware of and to use more natural fibers. There is an abundance of sources from which natural fibers can be extracted. Research efforts are refocusing on exploring alternative fiber crops, crop residues, and agricultural by-products, which are often underutilized. Presently there are some of the agricultural residues that have potential use in the area of textiles

that is scarcely extracted and utilized. Many are native to a particular region, depending on the climatic conditions required to grow. The value of the by-product depends on the availability and its abundance. Some such by-product are the stems of Castor, Neem and Turmeric which possess several medicinal properties which can form a potential source for production of textile fibers.

There are several types of bast fibers in the nature. Bast fibers are mostly extracted by the process of retting. Retting , sometimes termed as degumming plays an importance role in the yield of fiber as well as the quality (Ruzica Brunsek et.al, 2015).Some of them are not utilized fully to their extent and it has become a waste of unused resources.

Castor-oil plant (*Ricinus communis*), also called castor bean is large plant of the spurge family (Euphorbiaceae), grown commercially for the pharmaceutical and industrial uses of its oil and for use in landscaping (Go´mez et al. 2016; Salihu et al. 2014). The castor plant is a robust annual that may grow 6–15 feet (2–5 m) in one season with full sunlight and adequate moisture. In areas with mild, frost-free winters it may live for many years and become quite woody and treelike. There are several cultivated varieties with strikingly different foliage colorations, including black-purplish, dark red-metallic, bronze-green, maroon, bright green with white veins, and just plain green (Salihu et al. 2014)

Ricinus communis is one of the various kinds of plants that have capability to treat various types of disease. For thousands of years, many medicinal plants were used for the application of traditional treatments for many diseases (Monisha, 2017). It belongs to Euphorbiaceae family and commonly called as castor plant. Castor plant is small tree or large shrub and commonly found in tropical regions. It is 5m tall in height. It grows straight and then develop branches.

Neem – Scientifically known as *Azadirachta indica A*. is one of the well known tree famous for its properties which belongs to the Meliaceae family related to mahogany. Since the ancient times, Indian people have used the neem tree in various ways. In certain rural areas , many of them cleaned their teeth with the neem twigs, leaves have been used in many extracts in various application in different fields like pharmaceuticals, neutraceuticals etc.

Curcuma longa, or turmeric is a perennial herb and member of the Zingiberaceae (ginger) family and is cultivated extensively in Asia mostly in India and China. The rhizome, the portion of the plant used medicinally, yields a yellow powder. Dried Curcuma longa is the source of turmeric, the ingredient that gives curry powder its characteristic yellow color. It has many names such as Curcum in the Arab region, Indian saffron, Haridra (Sanskrit, Ayurvedic). Turmeric has been used in Asian cuisines for both its flavor and color and in the Chinese and

Ayurvedic medicine particularly as an anti-inflammatory and for the treatment of jaundice, menstrual difficulties, hematuria, hemorrhage, and colic (Labban, 2014).Turmeric fibers could be useful for wound dressings, textiles, composites and other applications (Manikandan Illangovan *et*. al 2018)

The survival of textile industry depends primarily on the diversification of end products to meet the customer demands. Diversification in the product can be obtained at various stages of production in yarn, fabric, design and fashion as well. Blends can be created with variegated novelty effect that caters to the fashion world today. Blending is done to produce a fabric, which is economical by combining the aesthetic comfort properties of the natural fibres. It also helps to provide the fabric's light weight with all desirable characteristics to improved spinning, weaving and finishing efficiency and the uniformity of product.

Main objectives of the study are as follows:

1. Conduct pilot study-consumer survey and literature survey to select herbal plants which yield fibre (Sanseviera cylindrica, Water-hyacinth, Castor, Neem, Turmeric) for the application of medical textiles.

2. Extract and evaluate fibres properties for selected parts of the plants (Castor, Turmeric and Neem) and soften with cellulase enzyme.

3. Blend and fabricate the extracted fibres with cotton in different proportions and apply with its respective oil (castor oil in castor cotton blend non-woven, neem oil in neem cotton blend non-woven, turmeric oil in turmeric cotton non-woven, and three oils in the combined non-woven blends) for the development of wound dressing materials.

4. Develop needle punched non-woven fabrics and apply the herbal oil treated and un-treated fabrics on animal (In-vivo excision wound healing study) to find out its effect.

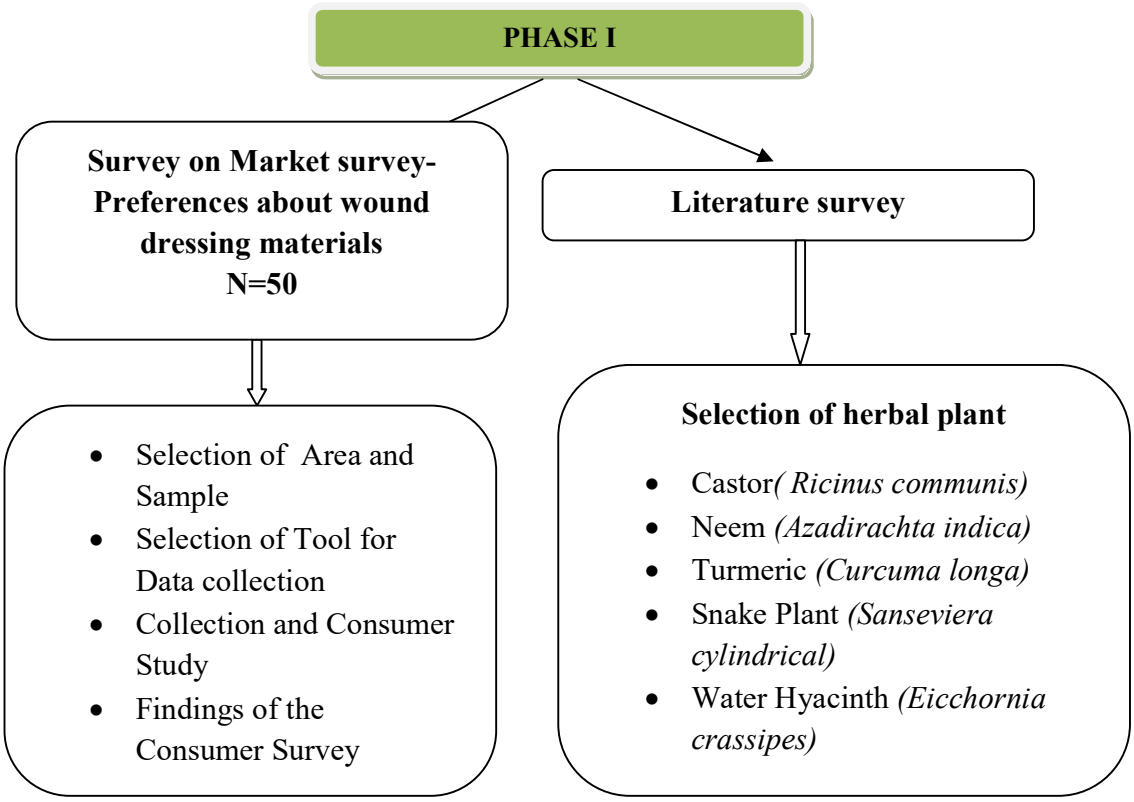
5. Estimate the cost of the product.

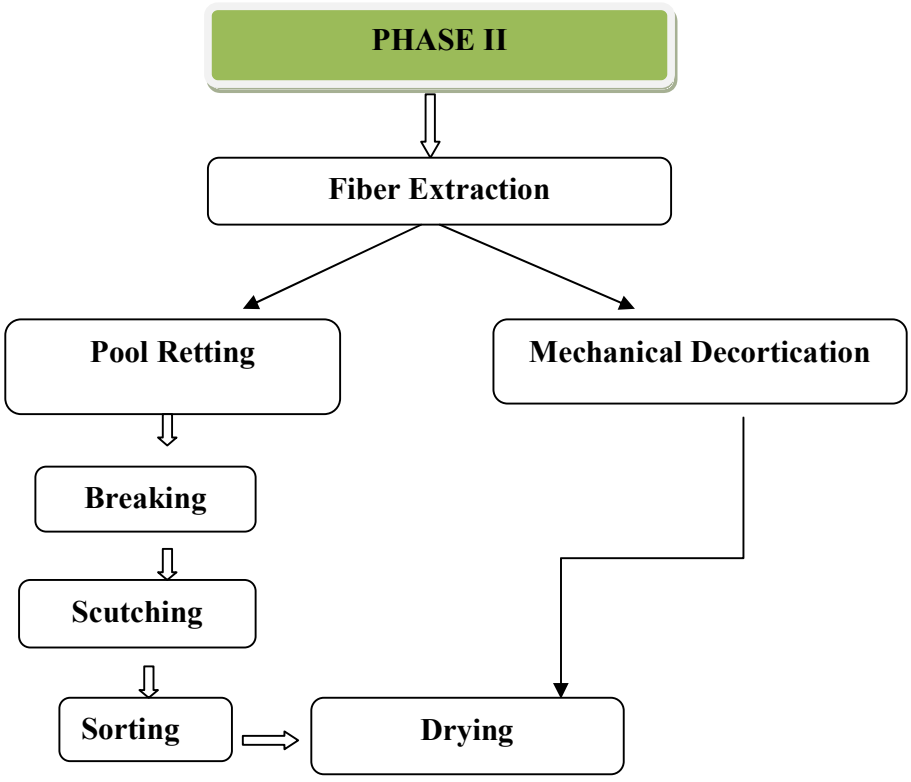
The review of the literature was discussed under the following concept as given below:

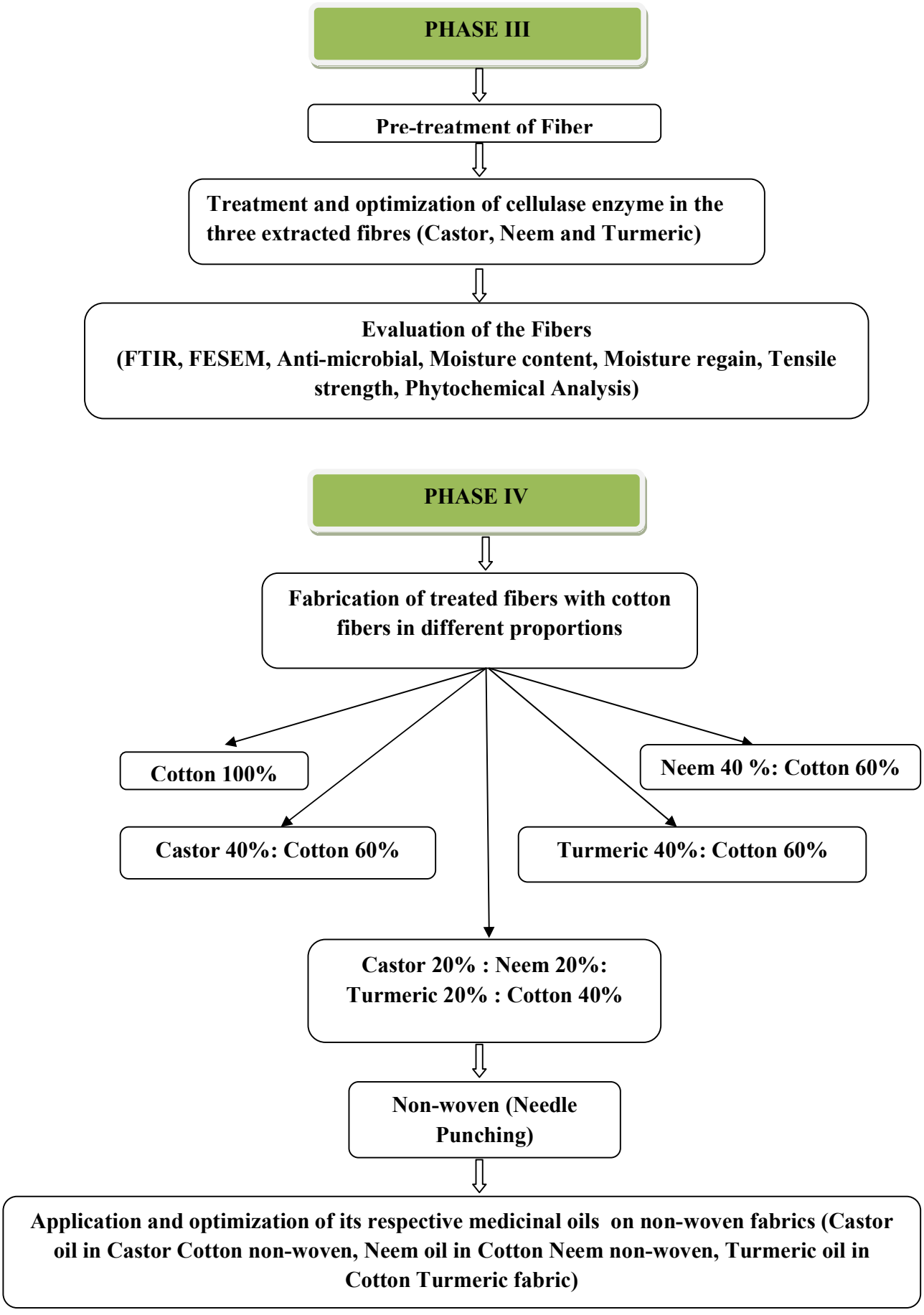
- Naturals fibers and its classification
- Bast fibers and its importance and applications
- Selected herbal sources and its properties
- Enzymes and its application in textiles
- Manufacturing process of non-woven's
- Applications of non-woven's in Medical textiles

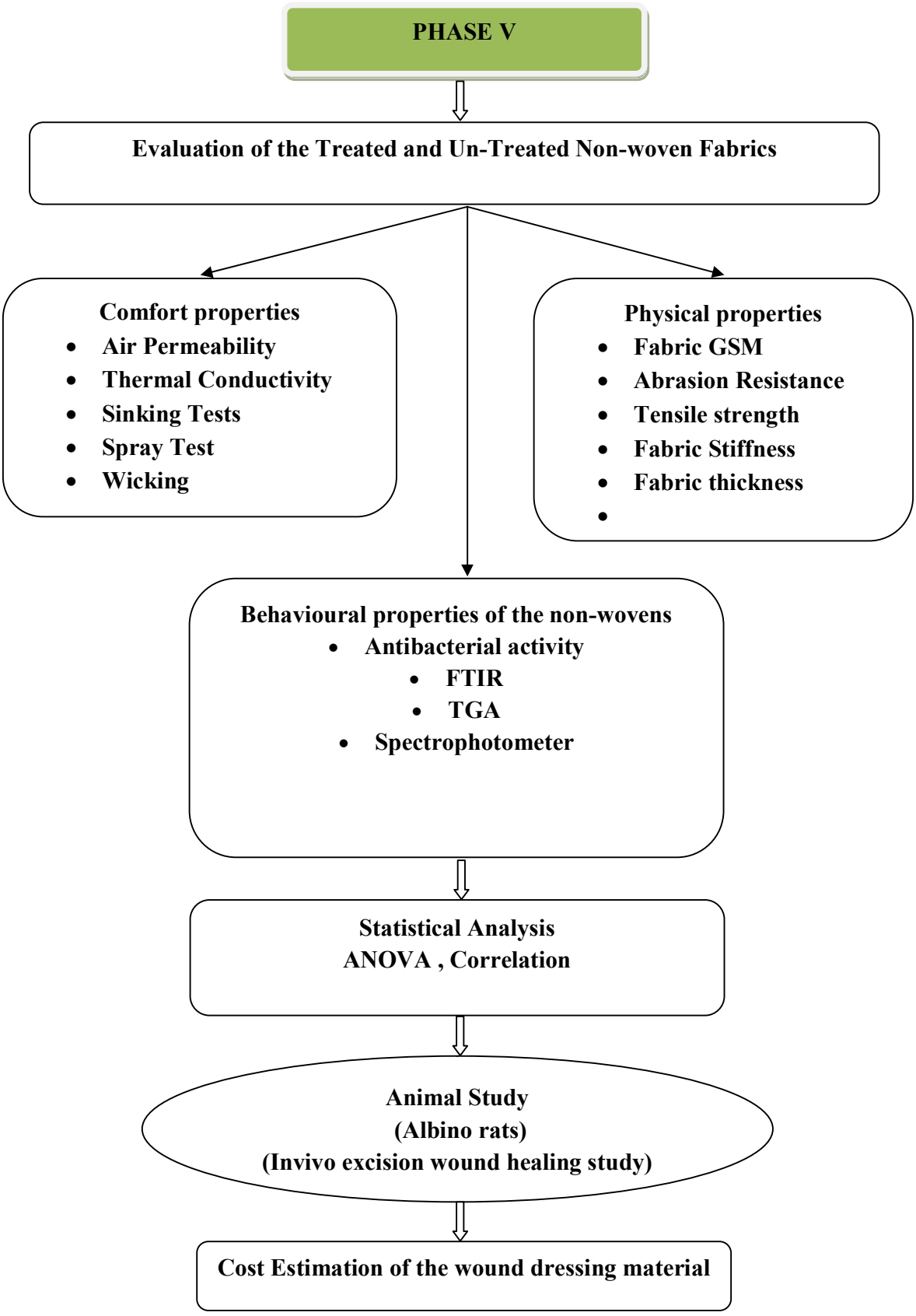
Methodology

"An Explorative study of Bast fibres for the application of Medical textiles"


PHASE I
Survey on Market survey- Preferences about wound dressing materials N=50
Literature survey
Selection of Area and Sample
Selection of Tool for Data collection
Collection and Consumer Study
Findings of the Consumer Survey
Selection of herbal plant
Castor(Ricinus communis)
Neem (Azadirachta indica)
Turmeric (Curcuma longa)
Snake Plant (Sanseviera cylindrical)
Water Hyacinth (Eicchornia crassipes)




PHASE III
Pre-treatment of Fiber
Treatment and optimization of cellulase enzyme in the three extracted fibres (Castor, Neem and Turmeric)
Evaluation of the Fibers
(FTIR, FESEM, Anti-microbial, Moisture content, Moisture regain, Tensile strength, Phytochemical Analysis)
PHASE IV
Fabrication of treated fibers with cotton fibers in different proportions
Cotton 100%
Neem 40 %: Cotton 60%
Castor 40%: Cotton 60%
Turmeric 40%: Cotton 60%
Castor 20% : Neem 20%: Turmeric 20% : Cotton 40%
Non-woven (Needle Punching)
Application and optimization of its respective medicinal oils on non-woven fabrics (Castor oil in Castor Cotton non-woven, Neem oil in Cotton Neem non-woven, Turmeric oil in Cotton Turmeric fabric)


PHASE V
Evaluation of the Treated and Un-Treated Non-woven Fabrics
Comfort properties
Air Permeability
Thermal Conductivity
Sinking Tests
Spray Test
Wicking
Physical properties
Fabric GSM
Abrasion Resistance
Tensile strength
Fabric Stiffness
Fabric thickness
Behavioural properties of the non-wovens
Antibacterial activity
FTIR
TGA
Spectrophotometer
Statistical Analysis
ANOVA , Correlation
Animal Study
(Albino rats)
(Invivo excision wound healing study)
Cost Estimation of the wound dressing material

PHASE I- The first phase deals with the conduct of survey on consumer preference about the wound dressing materials, collection of the data survey from the consumers in and around Coimbatore District. The selection of the herbal source was carried out after a thorough literature survey and pilot study. The three herbal source namely Castor, Neem and Turmeric were selected.

PHASE II- The second phase deals with the method of fiber extraction of the selected herbal plant stem. The two types of Retting were carried out- Pool retting and Mechanical Decortication. The two retted fibers were examined through visual inspection. The pool retted fibers were selected based on it for further study of the research work.

PHASE III- In this third phase , the pool retted fibers were treated with cellulase enzyme for softening of the extracted fibers. The enzyme treated fibers were evaluated for different types of test-FTIR, FESEM, Antimicrobial, Moisture content, Tensile strength, Phytochemical analysis.

PHASE IV- The fourth phase deals with the fabrication of the treated fibers with cotton fibers in different proportions (1.Cotton 100%, 2. Castor 50%: Cotton 50%, 3.Turmeric 50%: Cotton 50%, 4. Neem 50% : Cotton 50%, 5. Castor 20%: Neem 20%: Turmeric 20%: Cotton 40%). The fabrication was carried out by needle –punching method for the preparation of the non-wovens. Then, the non-wovens were treated with their respective oils i.e. Castor oil in Castor-Cotton fabric, Neem oil in Neem-Cotton fabric and Turmeric oil in Turmeric-Cotton fabric and combination of the three oils in the combined fabric**.**

PHASE V- The last phase deals with the animal study (rat experiment) of the treated and untreated non-woven fabrics. The excision wouns healing study were carried out to see their wound healing of the non-woven product developed. The statistical analysis was followed up for the study and the cost estimation was calculated.

Findings of the study:

Survey results: The result of the survey revealed that the consumer preferred to have a herbal source for the wound dressing materials. Non-woven fabric materials were preferred by the consumer. Hence castor, neem and turmeric fibres were chosen to make an innovative product for the medical textile.

Fiber Evaluation:

- Anti-bacterial analysis was conducted at the Advance Laboratory, Avinashilingam. The result showed that the three selected fibers possess a good antibacterial property against *E.coli* and *Staphylococcus aureus*.
- FTIR analysis- Fourier Transform infrared test was done to check the functional groups in the three fibers. It was found that several chemical groups like carboxyl , esters, bromides, alkanes, alkenes,fluorides, chlorides etc. were present in the three fibers.
- SEM analysis indicates the fiber morphological structure. The retted castor stalk fibre shows a uniform rod-like structure with a smooth surface. The neem twigs fibres showed

a slight serrated uneven structure and turmeric stem fibre SEM images showed depressions and serrated structure when compared to other fibres.

- Moisture Content- The three fibers was found to have a good moisture content of about 8.75%, 5.89% and 7.75% for castor, neem and turmeric fiber respectively.
- Moisture regain- Out of the three fibers, castor fiber have the highest moisture regain when compared to neem and turmeric which is 6.49 % and 7.34 %.
- Tensile breaking strength and elongation- castor fiber has the highest result of mean breaking strength of 364 gf than turmeric fibers which has 349 gf and Neem fiber has the lowest mean breaking strength.
- Phytochemical screening- Plants are more potent healers as they promote the curability and repair mechanisms in the natural way. Flavaoids, alkaloids, tannin, phenols and saponins were found to be present in castor, neem and turmeric fibers.

The non-woven were blended with cotton fibre and then treated with its respective therapeutic oils to increase its properties. As the three selected fibres possessed healing and antimicrobial properties, it could be used as the potential source of raw materials in healthcare textiles. The non-woven fabrics were then evaluated, analysed and found that the prepared non-woven showed a good air-permeability, good water repellence, good thermal conductivity property which could be used for the potential application for the development of technical textile materials. Fabric evaluation was done with and without the application of its respective therapeutic oils as given below:

- Antibacterial test were conducted for both the treated and untreated samples. The samples treated with their respective oils showed a better result as the zone of inhibition is larger in the treated samples when compared to untreated.
- FTIR- Both the treated and untreated fabrics was carried out for FTIR test. It was found that several functional groups were found to be in a higher peak level for the treated samples when compared to all the untreated samples.
- TGA- Thermal gravimetric analysis was done to measure the mass of the sample over time as the temperature changes. The application of the oils has increased the percentage of rate of degradation which will helps to degrade faster when compare to untreated samples.
- Comfort properties

  1.Air permeability- The untreated samples showed a higher air permeability values when compared to the treated samples. The standards ASTM D737-96 was followed for the air-permeability of non-wovens.

  2. Thermal conductivity- The standards ASTMC177 for thermal conductivity of non-woven was followed for the thermal conductivity of the non-woven samples. It was found that the treated samples showed slight higher values of thermal conductivity as compared with the treated samples.

  3. Spray test- Both the treated and untreated samples have carried out spray test by following the standards images given by the American Association of Textile Chemists and Colorists Scale. The result showed that the treated samples showed a slight random

sticking on wetting of upper surface where as the untreated samples showed a partial wetting of whole of upper surface. Therefore the treated samples showed a good water repellent property.

4. Sinking test- All the samples took time to sink in the water. Therefore both the treated and untreated samples were considered to be floated which indicates that non woven fabrics has lower capacity of water absorption.

- Mechanical test-
  1. Stiffness- The standards ASTM D5732 was followed for the stiffness test of non-woven fabrics. The result showed the bending length for the treated samples were slightly higher than the untreated samples increasing higher flexibility of the samples.
  2. Thickness- The fabric thickness was found to be almost similar for both the treated and untreated samples. The treated samples showed a very slight lower value of thickness than the untreated samples.
  3. Fabric weight- The weight of the treated non-woven fabrics was found to be higher when compared to the samples without the application of their respective oils.
  4. Abrasion resistance- The standards ASTM D3884 was followed for the abrasion resistance of the non-woven fabrics. It was found that the treated samples showed a lesser percentage of the loss of weight of the samples when compared to untreated samples.

UV-sterilizer: The developed product after several evaluations was sterilized using the UV-sterilizer for the use of rat study experiment. The UV-sterilizer will sterilize the prepared samples in order to protect from other kinds of infections during handling and preparation.

Animal study- The animal study experiment was conducted at the Animal House, Avinashilingam Institute. The albino wistar rat was selected for the study of wound healing. The age of the rats were about 8-12 weeks weighing of about 180-230 grams. The rats can be either male or female. Commercial pellets were fed to the rats. The excision wound healing procedure were followed (Liu,et al.2013). The sterilized developed products were used for the wound healing process in the animal study. The result of the animal study showed that the treated samples have a good wound healing properties when compared to the untreated samples. Among the treated and untreated samples, the samples with the turmeric samples showed the best result of wound healing when compared with the other samples. The treated turmeric sample showed a better wound healing and contraction when compared with the untreated turmeric sample.

Statistical analysis - The statistical tables showed the output of One-way ANOVA analysis, it shows that there is a statistical significant difference between treated and untreated samples in the form of Thickness, air permeability, spray test, sinking test, stiffness, fabric weight and abrasion resistance at 1% level, thermal conductivity were significant at 5% level. The results clearly explain there is an association between treated and untreated samples.

A Pearson correlation was run to determine the correlation between treated samples and untreated samples. There was a negative correlation between thickness and air permeability at 5% level ($r = -.652$, $p = .041$). Positive correlation between thickness and fabric weight at 5% level ($r = .727$, $p = .017$) and negative correlation between thermal conductivity and abrasion resistance at 5% level ($r = -.784$, $p = .007$).

Conclusion:

The fibers extracted from the three selected medicinal plants possess several medicinal properties of healing, antibacterial, anti-inflammatory which will be useful and beneficial for the development of Healthcare Textiles. In the present study, it was found that the needle punched nonwoven fabrics showed good air permeability, medium water repellence and a good thermal insulation. Among the untreated samples, the combination of three fibres with cotton (C+C+N+T) showed the highest air permeability. The untreated samples showed a better air permeability than the treated samples as the application of oil has slight effect on the passage of airflow and the thickness of the samples. For the thermal conductivity, both the treated and untreated has the Clo value of above 1 indicating the slow transfer of heat flow of the materials, the treated sample C+C having the highest Clo value. The treated samples showed a good property of water repellence and less absorbability which will be useful for developing water-proof technical textile materials. Among the treated and untreated samples, the samples with the turmeric samples showed the best result of wound healing when compared with the other samples. The treated turmeric sample showed a better wound healing and contraction when compared with the untreated turmeric sample. The time has come for the researchers to explore more about the underutilized plant fibres in order to have wider applications in technical textiles for various applications in day today life.

Recommendations for further study-

- The fiber proportions can be change, the needle punching parameters can be varied.
- The needle punched fabrics can also be evaluated for other applications in technical textiles.
- The fibers can be tried for woven structures as well as other types of non-woven manufacturing method for other textile applications.